NASA Contractor Report 181932

Spacecraft Orbit Design and Analysis (SODA) Version 1.0 User's Guide

Scott S. Stallcup
John S. Davis

Computer Sciences Corporation
Hampton, Virginia

Prepared For
Langley Research Center
under Contract NAS1-17999
August 1989

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23665-5225

Preface

This document describes the Spacecraft Orbit Design and Analysis (SODA) computer program, Version 1.0. SODA is a space-flight mission planning system which consists of five program modules integrated around a common database and user interface. SODA was developed by Computer Sciences Corporation for the Spacecraft Analysis Branch, Space Systems Division of NASA Langley Research Center. The goal of SODA is to provide a simple, integrated environment for spaceflight mission planning software.

SODA runs on a VAX/VMS[1] computer with graphics produced on an Evans & Sutherland PS300 graphics workstation. BOEING[2] RIM - Version 7 relational database management system performs transparent database services. In the current version, three program modules produce an interactive three-dimensional animation of one or more satellites in planetary orbit. Satellite visibility and sensor coverage capabilities are also provided. Circular and rectangular, off-nadir, fixed and scanning sensors are supported. One module produces an interactive three-dimensional animation of the solar system. Another module calculates cumulative satellite sensor coverage and revisit time for one or more satellites. Currently, Earth, Moon[3], and Mars systems are supported for all modules except the solar system module. SODA maintains orbit information, vehicle characteristics, vehicle sensor information, ground station locations, and other information required by each of the modules. The SODA user interface is terminal independent so data can be entered or edited on any terminal.

SODA owes some of its graphical heritage to MUTANI (A Multiple Trajectory Animation) and IVORY which is a program in SOAP (Satellite Orbit Analysis Package). Both MUTANI and SODA use the the ASTROLIB subroutine package for orbit propagation.

IVORY animates PATRAN[4] or NEVADA[5] spacecraft models with one articulating part in orbit about the Earth. IVORY evolved into VA (Vehicle Animation) module which animates a FLEXAN spacecraft model in orbit about the Earth, Moon, or Mars. FLEXAN is a flexible animation program which is called from within VA to process the spacecraft model files. VA supports animations of a spacecraft with hierarchical articulating parts and uses color and shape changes to represent temperatures, structural deformations, etc.

MUTANI animates one or more satellites in orbit about the Earth. Instantaneous on-nadir circular sensor coverage is also calculated and displayed. MUTANI evolved into the MVA (Multiple Vehicle Animation) module which produces animations of one or more satellites in orbit about the Earth, Moon, or Mars. Circular and rectangular off-nadir instantaneous sensor coverage is supported. Up to 10 sensors per vehicle are possible. Sensors

---

[1] VAX and VMS are registered trademarks of Digital Equipment Corporation.

[2] BOEING is a registered trademark of the Boeing Company.

[3] "Moon" refers to the natural satellite of the Earth. "moon" refers to any natural satellite of any other planet.

[4] PATRAN is a registered trademark of PDA Engineering.

[5] NEVADA is a registered trademark of Turner Associates Consultants.

may be fixed or scanning. Satellite-to-satellite and satellite-to-ground station line-of-sight visibility is also calculated and displayed.

The remaining three modules of SODA are completely original programs. The OD (Orbit Design) module animates a single spacecraft (an asterisk icon) in orbit about the Earth, Moon, or Mars. The SSS (Solar System Simulation) module animates the nine planets of the solar system for any specific time period. The CC (Cumulative Coverage) module calculates cumulative satellite sensor coverage as well as average and maximum revisit time.

SOAP and ASTROLIB were developed by the Aerospace Corporation. MUTANI was developed by M. F. Werner of the Aerospace Corporation. SODA was developed by Scott Stallcup of Computer Sciences Corporation (CSC). John Davis of CSC contributed many design suggestions. James Garrison of the Spacecraft Analysis Branch (SAB) developed the transformations required to support the Moon and Mars orbit propagations using ASTROLIB. Cheryl Allen of SAB digitized the maps of the Moon and Mars. Larry Rowell of SAB provided the direction and motivation needed to produce SODA.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Spacecraft Orbit Design and Analysis (SODA) computer program is a graphical tool for visualizing space-flight mission planning problems. SODA allows the mission planner to quickly and easily produce a three-dimensional, interactive animation oi one or more satellites in planetary orbit. The interactive animation of satellite trajectories, visibility periods, and sensor coverage frees the mission planner from the traditional analysis of tabular data produced from typical trajectory and satellite sensor coverage programs.

SODA consists of five program modules (see figure 1) integrated around a common database and user interface. SODA runs on a VAX/VMS (version 4.6 or later) computer with an Evans & Sutherland PS300 graphics workstation. In the current version, three modules produce an interactive three-dimensional animation of one or more satellites in planetary orbit. Satellite visibility and sensor coverage capabilities are also provided. Circular and rectangular, off-nadir, fixed, and scanning sensors are supported. One module produces an animation of the solar system with an ecliptic plane and background star field for any specific time period. Another module calculates cumulative sensor coverage and sensor revisit times and produces static raster pictures. Currently Earth, Moon[1], and Mars systems are supported for all modules except the solar system module.

SODA maintains orbit information, vehicle characteristics, vehicle sensor information, ground station locations, and other information required by each of the program modules in a BOEING[2] RIM Version 7 relational database. Because the SODA user interface is terminal independent , data can be entered or edited on any terminal. A PS300 graphics workstation is required to run the current modules: OD (Orbit Design), SSS (Solar System Simulation), VA (Vehicle Animation), MVA (Multiple Vehicle Animation), and CC (Cumulative Coverage).

The Evans & Sutherland PS300 family of graphics workstations supports real-time animations of wire-frame images. The PS300 dials and function keys are available for complete user control of animation sequences. SODA was developed specifically for the PS390, but the program will run on any PS300 system with little or no modifications required. A PS390 is required to display raster images.

CC produces generic raster data files. The SODA utility module DISPCC may be used to draw the pictures on the PS390 or to produce PostScript files and SDRC[3] (Structural Dynamics Research Corporation) I-DEAS[4] Picture files.

SSS animates the 9 planets of the solar system for any specific time period. A star field and an ecliptic plane are also available.

OD animates a single spacecraft (an asterisk icon) in orbit about the Earth, Moon, or Mars for the purpose of visualizing the effects of changes in any orbital

---

[1] "Moon" refers to the natural satellite of the Earth. "moon" refers to any natural satellite of any other planet.

[2] BOEING is a registered trademark of the Boeing Company. RIM Version 7 is a product of Boeing Computer Services, a division of the Boeing Company.

[3] SDRC is a service mark of Structural Dynamics Research Corporation.

[4] SDRC I-DEAS is a registered trademark of Structural Dynamics Research Corporation.

parameter. All of the classical orbital parameters may be manipulated with the dials of the PS300. A cumulative ground track may be drawn on the surface of the planet as the spacecraft orbits. A circular and a rectangular sensor are attached to the satellite. These sensors may be scaled and rotated off-nadir.

VA animates a spacecraft model in orbit about the Earth, Moon, or Mars. VA supports FLEXAN spacecraft geometry and time-history files. FLEXAN is a flexible animation program which is called from within VA to process the spacecraft model and time-history files. A vehicle may be animated in orbit with structural shape changes, color changes (temperature, stress, etc.), and/or rotating parts (solar arrays, scanning sensors, etc.)

MVA supports animations of Earth, Moon, and Mars systems. Asterisk icons represent spacecraft in three windows: an overview of the planet and satellites, a view of the sky from a fixed observer on the planet, and a Cartesian projection of the planet with moving satellites, ground tracks, and circular and rectangular off-nadir instantaneous sensor coverage. Up to 10 sensors per vehicle are possible. Sensors may be fixed or scanning. Satellite-to-satellite and satellite-to-ground station line-of-sight visibility is also calculated and displayed.

CC calculates cumulative satellite sensor coverage as well as average and maximum revisit time. CC is a batch-oriented program which produces three color-coded, raster pictures of the coverage data plotted onto Cartesian projections of the Earth, Moon, or Mars. One picture represents the total (cumulative) time of coverage. Another picture represents the average revisit time. The last picture represents the maximum revisit time.

The general scenario in using SODA is to enter vehicle, sensor, ground station information, etc. into the database using the various SODA commands and menus on the VAX/VMS host computer. A SODA module is run by issuing a module command. Arguments to the module command or prompts and responses identify the specific vehicle(s), sensor(s), and other information to be extracted from the database. The OD, SSS, VA, and MVA modules then calculate and send the animation information to the PS300 workstation. A "beep" is sounded when all of the animation information is received by the PS300. The <linelocal>, <term>, and <graph> keys on the PS300 toggle between the terminal (line) and graphics (local) modes. Animations are completely controlled by the dials and function keys of the PS300 while in graphics (local) mode.

CC submits a detached process on the VAX/VMS host computer. A generic raster file is produced when the detached process is completed. The DISPCC utility module may then be used to draw CC pictures on a PS390 or produce PostScript[5] and SDRC I-DEAS picture files.

[5] PostScript is a registered trademark of Adobe Systems Incorporated.

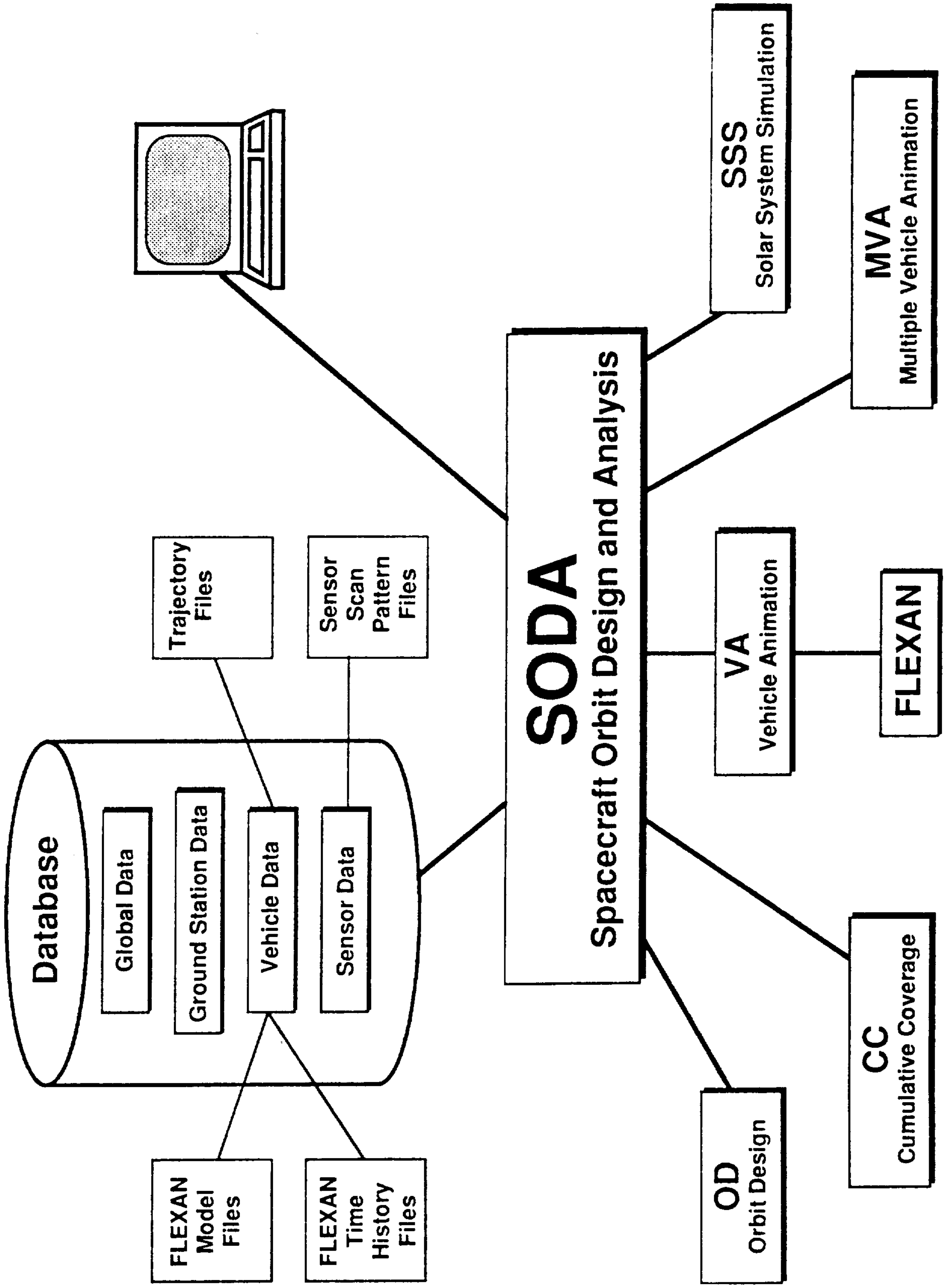

Figure 1 - Block Diagram of SODA

2.0 SODA Database

The SODA user interface is command driven. All commands and prompt responses are case insensitive and may appear anywhere on a line with any number of spaces between commands and parameters. All commands which are not SODA commands are passed-on to the VAX/VMS DCL command interpreter in a spawned process. This allows non-SODA commands to be issued without exiting the SODA system. SODA may be run from any terminal, though a PS300 must be available if SSS, VA, OD, or MVA are to be used. SODA is executed by issuing the SODA command:

$ SODA *dbname*

Where *dbname* is the name of a new or existing SODA (RIM7) database. *dbname* may include a full VMS path specification. If the database does not exist, then SODA will ask if the database should be created. A "yes" response will create and open the database. A "no" response yields an exit from SODA. A SODA database consists of three files named *dbname*1.dat , *dbname*2.dat, and *dbname*3.dat. If *dbname* is not supplied on the command line, then a prompt will be issued.

The /DEVICE = *device_number* command qualifier specifies a PS300 device to be used for all graphics. All terminal dialog is still performed on the current terminal. The *device_number* is an integer. The range of devices and the default is installation dependent. An example of the /DEVICE qualifier is:

$ SODA/DEVICE=2 *dbname*

The SODA command prompt is "*dbname* >". A SODA session is ended by entering "EXIT" or the *control* - Z character. The following terminal session creates and opens a new SODA database named "POP" and then exits using the "EXIT" command. This terminal session and the sessions to follow in this document are presented in a monospaced font with user responses bold-faced.

```
$ SODA POP

    Spacecraft Orbit Design & Analysis (SODA)
         NASA Langley Research Center
          Spacecraft Analysis Branch

                 Version 1.0

         Computer Sciences Corporation

POP does not exist,
would you like to create it (Y,N) -> Y

POP> EXIT
*** End SODA ***
$
```

2.1 Global Data

SODA maintains a list of values and options in the Global Data. Each of these values and options is used by one or more SODA program modules. The GLOBAL data items are:

1-6 **Epoch Date** - Numerical values for the reference year, month, day, hour, minute, and second. The epoch date is the reference date used for all orbit propagation calculations.

7 **Global Time Increment** - The time increment (time step) used for orbit propagation calculations and animation sequences.

8 **World Map** - Selects the size (level-of-detail) of the planetary map used in OD, MVA, VA, and CC. Larger maps cost more in time and memory requirements.

9 **Star Field** - Select from options for presenting a field of over 5,000 stars in OD, MVA, and SSS.

10 **Satellite-to-Satellite Links** - Select from options for the calculation and display of line-of-sight satellite-to-satellite links in MVA.

11 **Ground Station-to-Satellite Links** - Select from options for the calculation and display of line-of-sight ground station-to-satellite links in MVA.

The GLOBAL command, presented below, is used to edit the Global Data. The GLOBAL menu is typical of all SODA menus. A prompt for a new value is always issued when a numbered menu option is selected. Most prompts contain a default value between brackets "[ ]". The screen is refreshed after each prompt response is entered. The terminal session below and other sessions to follow assume an already open SODA database named POP.

```
POP> GLOBAL

Global Data

1  - Epoch Year......................... 1988.0
2  - Epoch Month........................ 1.0
3  - Epoch Day.......................... 1.0
4  - Epoch Hour......................... 1.0
5  - Epoch Minute....................... 1.0
6  - Epoch Second....................... 1.0
7  - Global Time Inc..(HRS)............. 0.25
8  - World Map.......................... Large
9  - Star Field......................... Yes
10 - Satellite-to-Satellite Links....... Yes
11 - Ground Station-to-Satellite Links.. No

Enter an item number to be corrected or X to return -> 2

Enter EPOCH month (1-12) -> 6
```

```
Global Data

1  - Epoch Year........................ 1988.0
2  - Epoch Month....................... 6.0
3  - Epoch Day......................... 1.0
4  - Epoch Hour........................ 1.0
5  - Epoch Minute...................... 1.0
6  - Epoch Second...................... 1.0
7  - Global Time Inc..(HRS)............ 0.25
8  - World Map......................... Large
9  - Star Field........................ Yes
10 - Satellite-to-Satellite Links....... Yes
11 - Ground Station-to-Satellite Links.. No

Enter an item number to be corrected or X to return -> 8

Enter Map Size (Small, Medium, Large) -> M

Global Data

1  - Epoch Year........................ 1988.0
2  - Epoch Month....................... 6.0
3  - Epoch Day......................... 1.0
4  - Epoch Hour........................ 1.0
5  - Epoch Minute...................... 1.0
6  - Epoch Second...................... 1.0
7  - Global Time Inc..(HRS)............ 0.25
8  - World Map......................... Medium
9  - Star Field........................ Yes
10 - Satellite-to-Satellite Links....... Yes
11 - Ground Station-to-Satellite Links.. No

Enter an item number to be corrected or X to return -> X
POP>
```

2.2 Vehicle Data

SODA maintains spacecraft and orbit information in named VEHICLE records. VEHICLE names may be 10 characters long with no intervening spaces. The items contained in each VEHICLE are listed below. The items are broken into two groups cr screens because all of the items will not fit on a standard 25-line by 80-column computer terminal.

Screen 1

1 **Vehicle Name** - Unique 10-character name of the vehicle.

2 **Planetary Body** - Planet to orbit. Currently the Earth, Moon, and Mars are supported.

3 **Propagation** - Select Keplerian or Keplerian with J2 effects propagation calculation.

4 **Groundtrack** - Select groundtrack calculation in MVA.

5 **Trajectory Lines** - Select solid or dotted trajectory lines in MVA.

6 **Color** - Select the color of the VEHICLE in MVA.

7 **Vehicle Start Time from Epoch** - The propagation start time, in hours, relative to the epoch date.

8 **Vehicle Stop Time from Epoch** - The propagation stop time, in hours, relative to the epoch date.

9 **Coordinate System** - Select the type of coordinate system to be used for specifying the orbital parameters. The following choices are available: Cartesian, Spherical, Classical, Geographic, and External Trajectory File. These coordinate systems correspond to those available in the ASTROLIB subroutine package. See Table 1 below.

10-15 **Orbital Parameters** - Each of these items is one orbital element in the coordinate system specified in item 9. Prompts and menu items change appropriately with the selected coordinate system. If the External Trajectory File option is selected in item 9, then item 10 contains the file name of an external trajectory file and items 11-15 are not used. See section 2.3 for a description of the trajectory file format.

Cartesian	Spherical	Classical	Geographic
X	Right Ascension (RA)	Semi-major axis	Longitude
Y	Declination	Eccentricity	Latitude
Z	Flight Path Angle	Inclination	Flight Path Angle
Velocity X	Azimuth	RA Ascending Node	Azimuth
Velocity Y	Dist. Planet Center	Arg. of Perigee	Dist. Planet Center
Velocity Z	Inertial Speed	Mean Anomaly	Inertial Speed

Table 1. - Satellite Coordinate Systems

Screen 2

1 **Model Filename** - FLEXAN geometry filename. This file is used in VA and will be described later.

2 **Color History Filename** - FLEXAN color history filename. This file is used in VA and will be described later.

3 **Delta History Filename** - FLEXAN delta history filename. This file is used in VA and will be described later.

4 **Rotation History Filename** - FLEXAN rotation history filename. This file is used in VA and will be described later.

5 **Vehicle Stabilization** - Select planet, orbit, space, or Sun vehicle stabilization.

6 **Type of Rotation** - Select coincident or rotated body (vehicle) coordinate system (BCS) and orbit coordinate system (OCS)

7-9 **(Yaw, Roll, Pitch) Angle** - Fixed yaw, roll and pitch angles. These items are only used if item 6 selects rotated coordinate systems.

The ADDV command creates a new VEHICLE. Prompts are issued for each item in the VEHICLE. An edit menu similar to the GLOBAL menu appears when all items have been entered. Prompts and menu items vary according to the options selected. The EDV command edits an existing VEHICLE. DELV deletes a VEHICLE from the database. And LISTV lists the current VEHICLEs in the database. The following terminal session uses all four commands.

```
POP> ADDV SAT1

Planetary Body

1 - Earth
2 - Moon
3 - Mars

Enter choice [1] ->

Type of Propagation

1 - Keplerian
2 - Keplerian with J2

Enter choice [1] -> 2

Groundtrack Type

1 - No Groundtrack
2 - Simple Line type Groundtrack

Enter choice [2] ->
```

Line Type

1 - Trajectory and Groundtracks are Dotted
2 - Trajectory and Groundtracks are solid lines

Enter choice [2] ->

Vehicle and Trajectory Color

```
  0 -  60 :     Blue    - Magenta
 60 - 120 :     Magenta - Red
120 - 180 :     Red     - Yellow
180 - 240 :     Yellow  - Green
240 - 300 :     Green   - Cyan
300 - 360 :     Cyan    - Blue
```

Enter choice [120.0] -> **240.0**

Enter Vehicle start time in HOURS [0.0] ->

Enter Vehicle stop time in HOURS [24.0] ->

Satellite Coordinate System

1 - Cartesian
2 - Spherical
3 - Classical
4 - Geographic
5 - EXTERNAL Trajectory File

Enter choice [3] ->

Enter SEMI-MAJOR AXIS -> **15000.0**

Enter ECCENTRICITY -> **.1**

Enter INCLINATION -> **23.5**

Enter RIGHT ASCENSION OF ASCENDING NODE -> **90.0**

Enter ARGUMENT OF PERIGEE -> **0.0**

Enter MEAN ANOMALY -> **90.0**

Enter a Model filename (or <cr>) -> **SAT1.GEO**

Enter a Color History filename (or <cr>) -> **SAT1.CHY**

Enter a Delta History filename (or <cr>) ->

Enter a Rotation History filename (or <cr>) -> **SAT1.RHY**

```
Vehicle Stabilization

1 - Planet Stabilized
2 - Orbit Stabilized
3 - Space Stabilized
4 - Sun Stabilized

Enter choice [1] ->

Type of Rotation

1 - BCS is Coincident with OCS
2 - Fixed Orientation of BCS to OCS

Enter choice [1] ->

Vehicle data #1 -- All units are hrs, km, and deg.

1  - Vehicle Name (Tag)...................... SAT1
2  - Planetary Body.......................... Earth
3  - Propagation............................. Keplerian with J2
4  - Groundtrack............................. Single line Groundtrack
5  - Trajectory Lines........................ Solid
6  - Color................................... 240.0
7  - Vehicle Start Time from Epoch........... 0.0
8  - Vehicle Stop Time from Epoch............ 24.0
9  - Coordinate System....................... Classical
10 - SEMI-MAJOR AXIS......................... 15000.0
11 - ECCENTRICITY............................ 0.1
12 - INCLINATION............................. 23.5
13 - RIGHT ASCENSION OF ASCENDING NODE....... 90.0
14 - ARGUMENT OF PERIGEE..................... 0.0
15 - MEAN ANOMALY............................ 90.0

Enter an item number to be corrected, or
<CR> to go to next screen, or
"X" to end ->

Vehicle data #2 -- All units are hrs, km, and deg.

1  - Model Filename................... SAT1.GEO
2  - Color History Filename........... SAT1.CHY
3  - Delta History Filename...........
4  - Rotation History Filename........ SAT1.RHY
5  - Vehicle Stabilization............ Planet Stabilized
6  - Type of Rotation................. BCS Coincident with OCS

Enter an item number to be corrected, or
<CR> to go to next screen, or
"X" to end -> x
```

```
POP> EDV SAT1

Vehicle data #1 -- All units are hrs, km, and deg.

1  - Vehicle Name (Tag)..................... SAT1
2  - Planetary Body......................... Earth
3  - Propagation............................ Keplerian with J2
4  - Groundtrack............................ Single line Groundtrack
5  - Trajectory Lines....................... Solid
6  - Color.................................. 240.0
7  - Vehicle Start Time from Epoch........... 0.0
8  - Vehicle Stop Time from Epoch............ 24.0
9  - Coordinate System...................... Classical
10 - SEMI-MAJOR AXIS........................ 15000.0
11 - ECCENTRICITY........................... 0.1
12 - INCLINATION............................ 23.5
13 - RIGHT ASCENSION OF ASCENDING NODE....... 90.0
14 - ARGUMENT OF PERIGEE.................... 0.0
15 - MEAN ANOMALY........................... 90.0

Enter an item number to be corrected, or
<CR> to go to next screen, or
"X" to end -> X
POP> LISTV

Current Vehicles - 1

  SAT1

POP> DELV SAT1
POP>
```

2.3 Vehicle Trajectory File Format

The vehicle trajectory file format is the same as that described in the ASTROLIB documentation (ref. 3). Trajectory files are unformatted files of 7-word records. Each record contains the time, inertial position vector, and the inertial velocity vector. SODA does not support the acceleration vector option described in the ASTROLIB documentation. SODA / ASTROLIB performs a Hermite interpolation to propagate the vehicle for the selected time period. The following FORTRAN code fragment shows how to write this file.

```
      .
      .
      .
      DOUBLE PRECISION  TIME(500), POS(3,500), VEL(3,500)
      .
      .
      .
      OPEN(10,FILE='TRAJ.DAT',FORM='UNFORMATTED')
      DO 100 J = 1, 500
           WRITE(10)    TIME(J),
     1                  POS(1,J), POS(2,J), POS(3,J),
     2                  VEL(1,J), VEL(2,J), VEL(3,J)
100   CONTINUE
      CLOSE(10)
      .
      .
      .
```

2.4 Sensor Data

SODA maintains sensor information in named SENSOR records. SENSOR names may be 10 characters long with no intervening spaces. SODA supports circular and rectangular sensors. Sensors are described in the vehicle coordinate system where the origin is the geometric center of the vehicle. Positive Z points at the center of the planet. Positive X points in the direction of the vehicle velocity vector. Positive Y completes the right-handed coordinate system. The center axis or *Boresight* axis of the on-nadir sensor corresponds to the positive Z-axis.

Circular sensors are described by a half-cone angle; the angle from the boresight axis to the edge of the sensor cone. Rectangular sensors are described by intrack and crosstrack half-cone angles from the boresight axis to the adjacent sides of the viewing pyramid. Intrack angles are formed in the XZ plane of the vehicle coordinate system. Crosstrack angles are formed in the YZ plane of the vehicle coordinate system. Off-nadir sensors are described by rotating the sensor cone in any desired direction.

An external file of scan instructions may be supplied for scanning sensors. See Section 2.5 for a description of the sensor scan pattern file format. SODA calculates the sensor position for scanning sensors at each time step of the simulation.

The items contained in each SENSOR are listed below. Items 1 - 5 are required for all SENSORs. Items 6 - 10 may be required depending on the SENSOR and scan types.

1 **Sensor Name** - Unique 10-character name of sensor.

2 **Sensor Type** - Select circular or rectangular sensor.

3 **Scan Type** - Select a fixed or scanning sensor.

4 **Graphical Increment** - Increment value for modeling the edges of the sensor cone (determines the number of vectors in the sensor polygon). A value of 1.0 for a circular sensor results in 360 vectors in the sensor model. Rectangular sensors are calculated parametrically from -1.0 to 1.0 on each of the four sides. A value of 0.1 results in 20 vectors per side and a total of 80 vectors for the complete rectangular sensor. Low values yield more vectors and higher accuracy calculations at the cost of longer runs.

5 **Sensor Coverage Color** - Select the color of the coverage area in MVA.

6-10 **Half Cone Angle** - Angle from the boresight vector to the edge of the circular sensor cone.

Intrack Cone Angle - Angle from the boresight vector to the edge of the rectangular sensor pyramid in the XZ plane.

Crosstrack Cone Angle - Angle from the boresight vector to the edge of the rectangular sensor pyramid in the YZ plane.

Fixed Off-nadir Angle in (X,Y,Z) - Off-Nadir Rotation angles in the X, Y, Z directions (applied in that order) of the boresight axis. Appears in non-scanning sensors only.

External Scan Pattern File - Filename of scan instructions.

The ADDS command creates a new SENSOR record. Prompts are issued for each item in the SENSOR. An edit menu similar to the GLOBAL menu appears when all items have been entered. Prompts and menu items vary according to the options selected. The EDS command edits an existing SENSOR. DELS deletes a SENSOR from the database. And LISTS lists the current SENSORs in the database. The following terminal session uses all four commands.

```
POP> ADDS SEN1

SENSOR DATA  -- Vehicle Coordinates.
Positive Z points at the center of the planet.  Positive X points in the
direction of motion.  And positive Y points out the right wing.

Sensor Type

1 - Circular
2 - Rectangular

Enter choice [1] -> 2

Scan Type

1 - Fixed
2 - Scanning

Enter choice [1] ->

Enter Graphical Increment value [0.05] ->

Sensor Coverage Color

  0 -  60 :     Blue    - Magenta
 60 - 120 :     Magenta - Red
120 - 180 :     Red     - Yellow
180 - 240 :     Yellow  - Green
240 - 300 :     Green   - Cyan
300 - 360 :     Cyan    - Blue

Enter choice [240.0] ->

Enter Sensor Intrack Cone Angle [20.0] ->

Enter Sensor Crosstrack Cone Angle [20.0] -> 10.0

Enter Fixed Off-nadir Angle in X [0.0] ->

Enter Fixed Off-nadir Angle in Y [0.0] -> 10.0

Enter Fixed Off-nadir Angle in Z [0.0] -> 12.0
```

```
SENSOR DATA  -- Vehicle Coordinates.
Positive Z points at the center of the planet.  Positive X points in the
direction of motion.  And positive Y points out the right wing.

1  - Sensor Name............................ SEN1
2  - Sensor Type............................ Rectangular
3  - Scan Type.............................. Fixed
4  - Graphical Increment.................... 0.05
5  - Sensor Coverage Color.................. 240.0
6  - Intrack Cone Angle..................... 20.0
7  - Crosstrack Cone Angle.................. 10.0
8  - Fixed Off-nadir Angle in X............. 0.0
9  - Fixed Off-nadir Angle in Y............. 10.0
10 - Fixed Off-nadir Angle in Z............. 12.0

Enter an item number to be corrected, or
"X" to end -> 3

Scan Type

1 - Fixed
2 - Scanning

Enter choice [1] -> 2


Enter External Scan Filename -> SEN1.SCN

SENSOR DATA  -- Vehicle Coordinates.
Positive Z points at the center of the planet.  Positive X points in the
direction of motion.  And positive Y points out the right wing.

1  - Sensor Name............................ SEN1
2  - Sensor Type............................ Rectangular
3  - Scan Type.............................. Scanning
4  - Graphical Increment.................... 0.05
5  - Sensor Coverage Color.................. 240.0
6  - Intrack Cone Angle..................... 20.0
7  - Crosstrack Cone Angle.................. 10.0
8  - External Scan File..................... SEN1.SCN

Enter an item number to be corrected, or
"X" to end -> X
POP> EDS SEN1
```

```
SENSOR DATA  -- Vehicle Coordinates.
Positive Z points at the center of the planet.  Positive X points in the
direction of motion.  And positive Y points out the right wing.

1  - Sensor Name............................ SEN1
2  - Sensor Type............................ Rectangular
3  - Scan Type.............................. Scanning
4  - Graphical Increment.................... 0.05
5  - Sensor Coverage Color.................. 240.0
6  - Intrack Cone Angle..................... 20.0
7  - Crosstrack Cone Angle.................. 10.0
8  - External Scan File..................... SEN1.SCN

Enter an item number to be corrected, or
"X" to end -> X
POP> LISTS

Current Sensors - 1

  SEN1

POP> DELS SEN1
POP>
```

2.5 Sensor Scan Pattern File Format

Sensor scan pattern files are unformatted files of 4-word records. Each record contains the time and the off-nadir sensor rotations in the X, Y, and the Z directions expressed in the vehicle coordinate system described in Section 2.4. The rotation calculations are performed in the same order. SODA performs a Hermite interpolation to calculate the sensor rotation at each time step of MVA and CC. The following FORTRAN code fragment shows how to write this file.

```
      .
      .
      .
      DOUBLE PRECISION  TIME(500), ROT(3,500)
      .
      .
      .
      OPEN(10,FILE='SCAN.DAT',FORM='UNFORMATTED')
      DO 100 J = 1, 500
           WRITE(10)    TIME(J), ROT(1,J), ROT(2,J), ROT(3,J),
100   CONTINUE
      CLOSE(10)
      .
      .
      .
```

2.6 Ground Station Data

SODA maintains ground station information in named STATION records. STATIONs may be 10 characters long with no intervening spaces. The VAX/VMS EDT text editor is used for entering and editing STATIONs; though all data is stored in the database. The STATION command presents instructions to the terminal, then gets the ground stations from the database and places them in a scratch file. The EDT editor is started. Ground stations may be added, deleted, etc. The EDT EXIT command saves the new ground stations to the scratch file and ultimately the SODA database. The EDT QUIT command discards any changes to the ground stations. The scratch file is deleted after the database is updated. The following terminal session demonstrates the STATION command using the EDT line mode (any of the EDT editing modes may be used).

```
POP> STATION
      Use the VAX editor to enter/update the ground stations.
The data for each ground station must appear on a single line
with one or more blanks between each item.

Planet Flag:  1,2,3 for Earth, Moon, Mars respectively.

Name:  Ground station Name, only the first 10 char. recognized.

Color:    0 -  60 : Blue     - Magenta
         60 - 120 : Magenta  - Red
        120 - 180 : Red      - Yellow
        180 - 240 : Yellow   - Green
        240 - 300 : Green    - Cyan
        300 - 360 : Cyan     - Blue

Longitude:     -180.0 to 180.0 deg.

Latitude:      -90.0 to 90.0 deg.

    PLANET_FLAG    NAME          COLOR   LONGITUDE  LATITUDE
-------------------------------------------------------------
    1        1    HERE          240.000     60.000     30.000
*1:2
    1        1    HERE          240.000     60.000     30.000
    2        2    THERE         100.000      0.000     40.000
*EXIT
U2A:[CSC7.ES.SODA_FLEX]TSTAT.DAT;2 2 lines

POP>
```

3.0 SSS - Solar System Simulation

Solar System Simulation (SSS) animates the 9 planets of the solar system for any specific time period. A star field and an ecliptic plane are also available. Figure 2 is a still frame taken from an SSS animation. SSS uses the global epoch date as the start time of the animation. A prompt is issued for the number of days to animate. The time increment is 1 day. The following terminal session demonstrates the SSS command.

```
POP> sss

Enter the number of days to animate [365.25] ->

POP>
```

The solar system is shown to scale. The dials may be used to scale the Sun and planets. The scale factors are displayed in the lower right corner along with the day (or animation frame number) of the animation. The ecliptic plane is drawn in green and can be toggled on or off. Solid curves mark the trajectory of each planet during the simulation time period. Dotted curves mark the complete orbit of each planet. The MOTION key starts the animation. The planets move along the simulated trajectories until the end of the sequence. The PS300 function keys and dials are presented in Tables 2 and 3 respectively.

Keyset

Key	Label	Function
1	MOTION	Toggle motion of the planets.
2	KEYS	Not Used (for future expansion).
3	DIALS	Toggle dialsets.
4	VIEWS	Not Used (for future expansion).
5		
6	STARS	Toggle star magnitudes.
7	ECLIPTIC	Toggle ecliptic plane.
8	LABELS	Toggle display labels.
9	PLANETS	Toggle planets.
10	PLAN TAG	Toggle planet tags (names).
11	PLAN TRJ	Toggle planet solid trajectory for simulation time.
12	PLAN DOT	Toggle planet dotted trajectory (completes the orbit).

Table 2 SSS - Function Keys

Dialset #1

Dial	Label	Function
1	X TRAN	Translate Solar System in the X direction.
2	Y TRAN	Translate Solar System in the Y direction.
3	Z TRAN	Translate Solar System in the Z direction.
4		
5	X ROTATE	Rotate Solar System in the X direction.
6	Y ROTATE	Rotate Solar System in the X direction.
7	Z ROTATE	Rotate Solar System in the X direction.
8		

Dialset #2

Dial	Label	Function
1	PLA SIZE	Scale the planets.
2	SUN SIZE	Scale the Sun.
3		
4		
5		
6		
7		
8		

Table 3 SSS - Dialsets

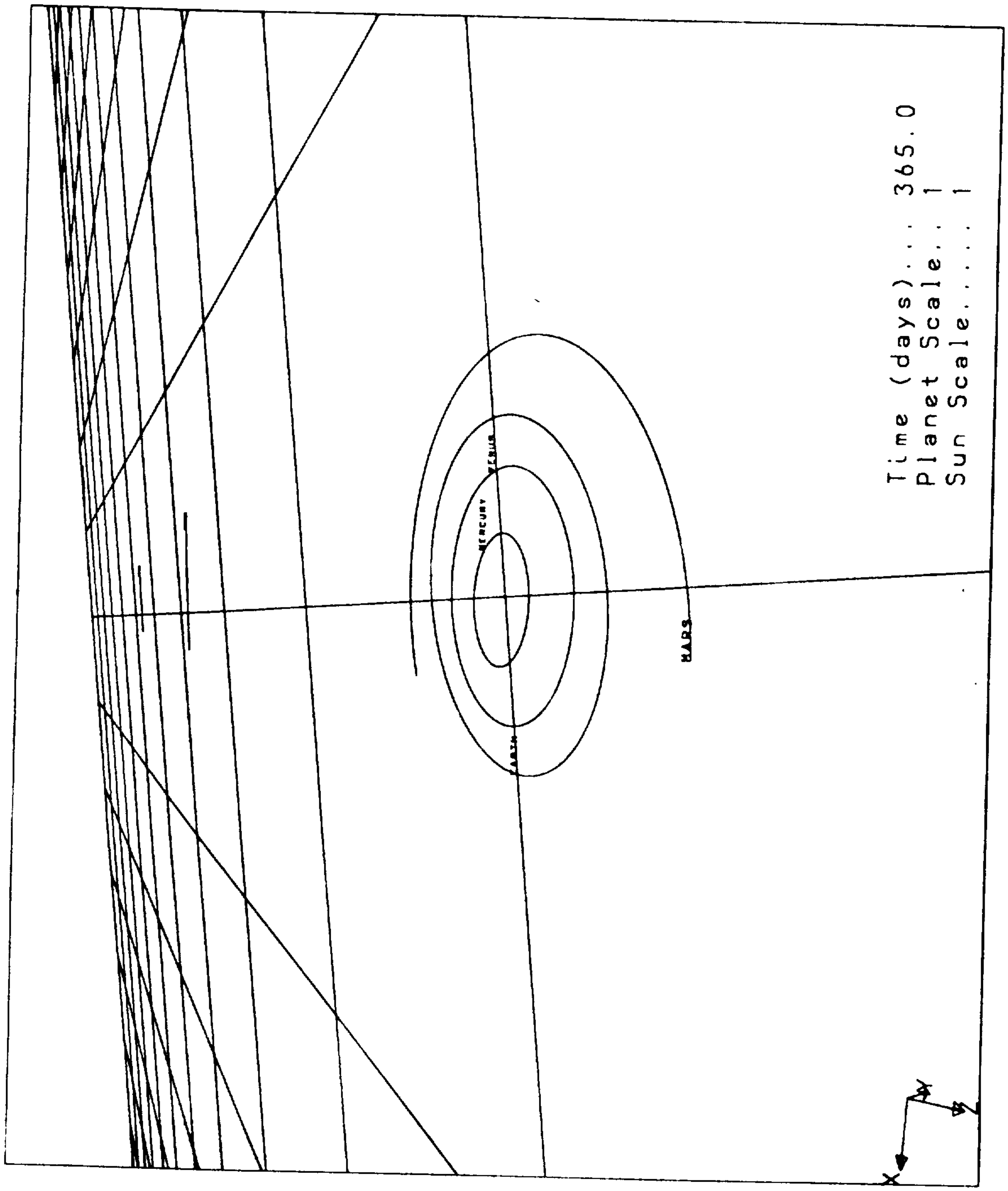

Figure 2 - Still Picture from SSS

4.0 OD - Orbit Design

Orbit Design (OD) animates a single spacecraft (an asterisk icon) in orbit about the Earth, Moon, or Mars. All of the classical orbital parameters may be manipulated by using the dials of the PS300. A cumulative ground track may be displayed on the surface of the planet. A circular and a rectangular sensor are attached to the satellite. These sensors may be scaled and rotated off-nadir. Figure 3 is a still frame taken from an OD session. The OD command requires one argument - a VEHICLE name. The orbital parameters of the VEHICLE record are used to initialize the OD session and choose the planet to be orbited. OD will not change any items in the VEHICLE record. The following terminal session demonstrates the OD command.

```
POP> OD SAT1
POP>
```

The PS300 function keys and dials are presented in Tables 4 and 5 respectively.

Keyset #1

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Not Used (for future expansion).
5		
6	STARS	Toggle background star magnitudes.
7	MAP	Toggle continents (features) of planet.
8	LIMB	Toggle planetary limb.
9	GRID	Toggle planetary grid lines.
10	LABELS	Toggle display labels.
11	STATIONS	Toggle ground stations.
12	SHADOW	Toggle planetary shadow.

Keyset #2

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Not Used (for future expansion).
5		
6	ORBIT	Toggle vehicle orbit.
7	CIRC SEN	Toggle circular sensor.
8	RECT SEN	Toggle rectangular sensor.
9	EQ PLANE	Toggle equatorial plane.
10	START GT	Start ground track display.
11	STOP GT	Stop ground track display.
12	RESET GT	Reset the ground track.

Keyset #3

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Not Used (for future expansion).
5		
6	VEH AXIS	Toggle vehicle coordinate axis.
7		
8		
9		
10		
11		
12		

Table 4 OD - Function Keys

Dialset #1

Dial	Label	Function
1	HORZNTAL	Translate the animation horizontally.
2	VERTICAL	Translate the animation vertically.
3	DEPTH	Translate the animation in Z (depth cueing).
4	SCALE	Scale the animation.
5	X ROTATE	Rotate the animation in the X direction.
6	Y ROTATE	Rotate the animation in the Y direction.
7	Z ROTATE	Rotate the animation in the Z direction.
8	VEH SCAL	Scale the vehicle.

Dialset #2

Dial	Label	Function
1	SEMI AXS	Semi-major axis.
2	ECCNTRTY	Eccentricity.
3	INCLNATN	Inclination.
4	INCREMEN	Propagation increment (animation speed).
5	RA ASC N	Right Ascension of the ascending node.
6	ARG PERI	Argument of perigee.
7	MEAN ANO	Mean Anomaly.
8	VEH AX S	Scale vehicle axis.

Dialset #3

Dial	Label	Function
1	CIRC SCL	Scale the circular sensor.
2	HALFCONE	Halfcone angle of the circular sensor.
3		
4		
5	NADIR X	Rotate circular sensor off-nadir in X.
6	NADIR Y	Rotate circular sensor off-nadir in Y.
7	NADIR Z	Rotate circular sensor off-nadir in Z.
8		

Dialset #4

Dial	Label	Function
1	RECT SCL	Scale the rectangular sensor.
2	INTRACK	Intrack half angle of the rectangular sensor.
3	CROSSTRA	Crosstrack half angle of the rectangular sensor.
4		
5	NADIR X	Rotate rectangular sensor off-nadir in X.
6	NADIR Y	Rotate rectangular sensor off-nadir in Y.
7	NADIR Z	Rotate rectangular sensor off-nadir in Z.
8		

Table 5 OD - Dialsets

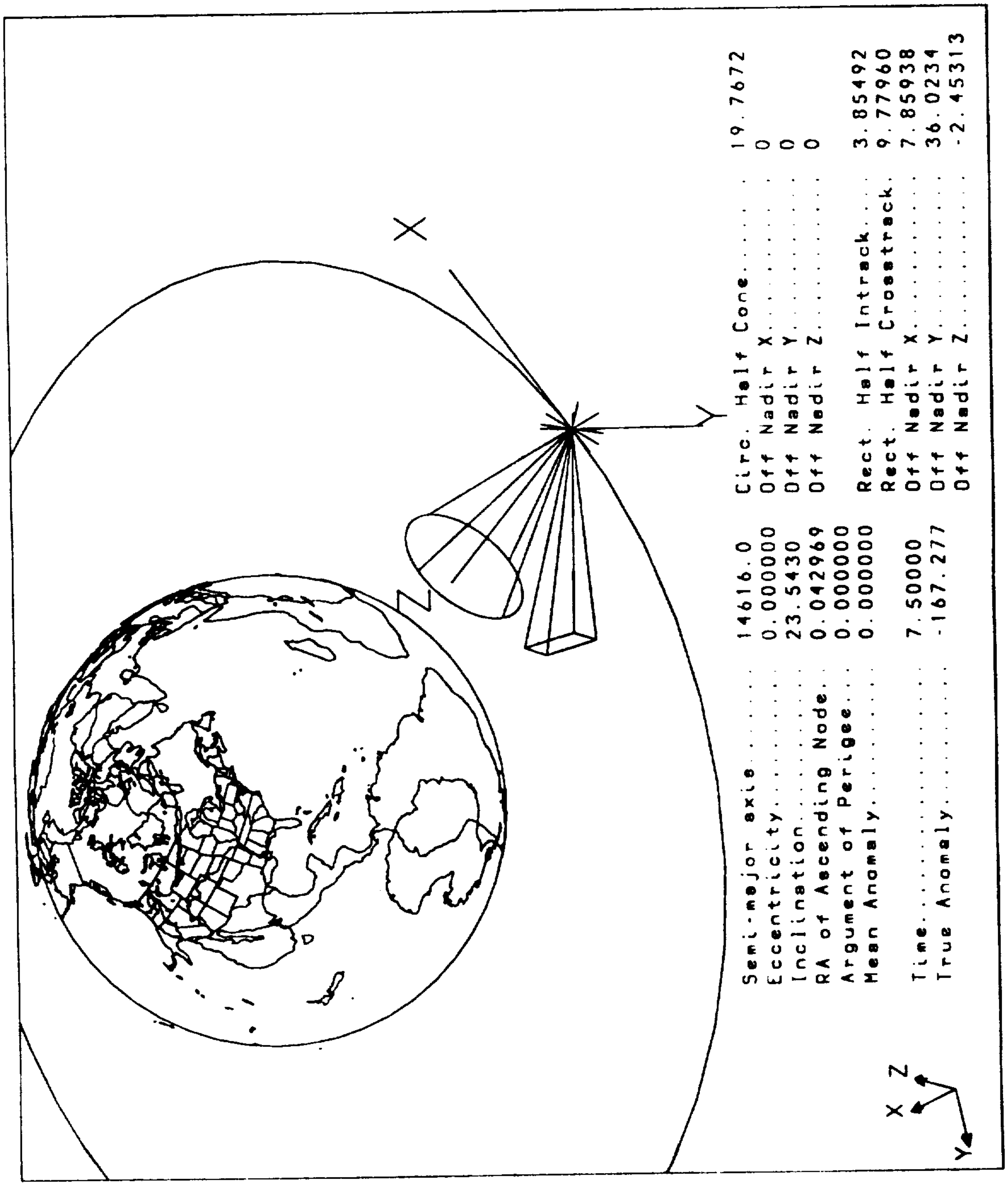

Figure 3 - Still Picture from OD

5.0 VA - Vehicle Animation

Vehicle Animation (VA) animates a spacecraft model in orbit about the Earth, Moon, or Mars. VA supports FLEXAN spacecraft geometry and time-history files. A vehicle can be animated in orbit with structural shape changes, color changes (temperature, stress, etc.), and/or rotating parts (solar arrays, scanning sensors etc.) VA does not calculate stresses, temperatures, or rotation angles; it only reads data files produced by other programs. FLEXAN is completely described in ref. 6. Figure 4 is a still frame from a typical VA animation. The VA command takes one argument - a VEHICLE name. The following terminal session demonstrates the VA command.

```
POP> VA SAT1
POP>
```

All of the items in the VEHICLE record except the color and groundtrack information are used in VA. A FLEXAN model file is required but the FLEXAN time history files (color, delta, and rotation) are optional. Any combination of FLEXAN time history files, including all three is acceptable. Vehicle models should be represented in the vehicle coordinate system described in section 2.3. VA will scale the vehicle to fit the animation windows. The FLEXAN file formats are completely described in the FLEXAN document (ref. 6).

Currently VA requires exactly 180 frames of data in the FLEXAN time history files. Each data frame represents the state of the vehicle at a particular point (every 2 degrees of true anomaly) in one complete orbit .

VA animates the vehicle in several views : planet-to-satellite, Sun-to-satellite, overview planet (orbit and vehicle included), overview satellite, and satellite-to-ground.

The PS300 function keys and dials are presented in Tables 6 and 7, respectively.

Keyset #1

Key	Label	Function
1	KEYS	Toggle keysets.
2	NEXTVIEW	Toggle views.
3	PLANET/SAT	Toggle dialsets (planet, satellite).
4	SOLAR	Toggle planetary shadow.
5	MERIDIAN	Toggle meridian (limb).
6	PLANET	Toggle planet continents (features).
7	ORBIT	Toggle vehicle orbit.
8	ECLIPTIC	Toggle ecliptic plane.
9	EQUATOR	Toggle equatorial plane.
10	BCS	Toggle body coordinate axis.
11	OCS	Toggle orbit coordinate axis.
12	TRIGGER	Toggle animation.

Keyset #2

Key	Label	Function
1	KEYS	Toggle keysets.
2	NEXTVIEW	Toggle views.
3	PLANET/SAT	Toggle dialsets (planet, satellite).
4	RESCALE	Rescale display to the default.
5	START	Start ground track.
6	STOP	Stop ground track.
7	RESET	Reset ground track.
8		
9		
10		
11		
12	TRIGGER	Toggle animation.

Table 6 VA - Function Keys

Dialset #1

Dial	Label	Function
1	ROTATE X	Rotate overview planet in the X direction.
2	ROTATE Y	Rotate overview planet in the Y direction.
3	ROTATE Z	Rotate overview planet in the Z direction.
4	SCALE	Scale overview planet .
5	HORZNTAL	Translate overview planet horizontally.
6	VERTICAL	Translate overview planet vertically.
7	DEPTH	Translate overview planet in Z (depth cueing).
8	SPEED	Speed of animation.

Dialset #2

Dial	Label	Function
1	ROTATE X	Rotate overview satellite in the X direction.
2	ROTATE Y	Rotate overview satellite in the Y direction.
3	ROTATE Z	Rotate overview satellite in the Z direction.
4	SCALE	Scale overview satellite.
5	HORZNTAL	Translate overview satellite horizontally.
6	VERTICAL	Translate overview satellite vertically.
7	DEPTH	Translate overview satellite in Z (depth cueing).
8	HALFCONE	Speed of animation.

Table 7 VA - Dialsets

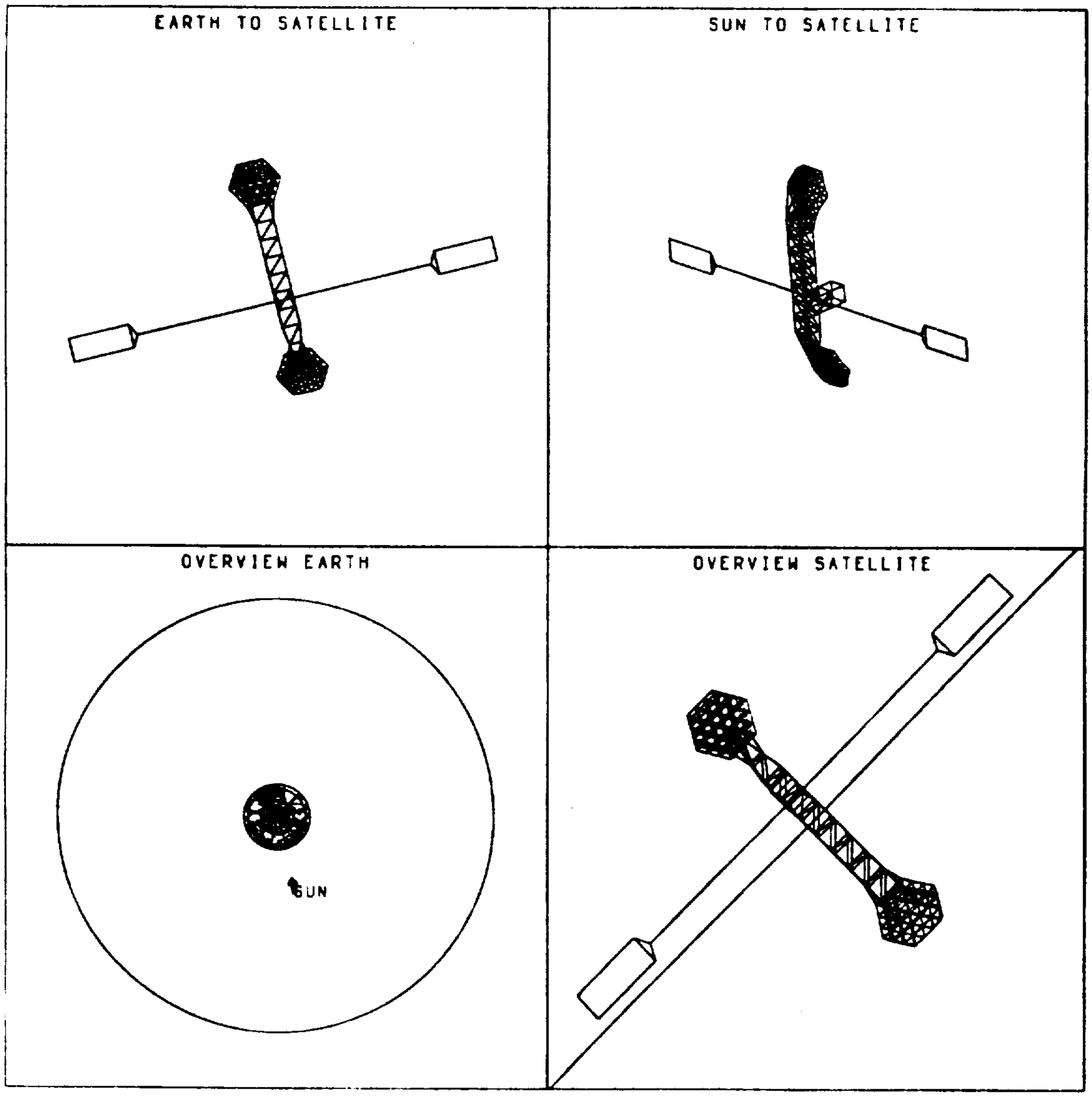

Figure 4 - Still Picture from VA

6.0 MVA - Multiple Vehicle Animation

Multiple Vehicle Animation (MVA) supports animations of Earth, Moon, and Mars systems. Asterisk icons represent spacecraft in three windows - an overview of the planet, and satellites, a view of the sky from a ground observer on the planet and a Cartesian projection of the planet with moving satellites, ground tracks, and circular and rectangular off-nadir instantaneous sensor coverage. Up to 10 sensors per vehicle are possible. Sensors may be fixed or scanning. Satellite-to-satellite and satellite-to-ground station line-of-sight visibility is also calculated and displayed. Figure 5 is a still frame taken from an MVA session in which two vehicles, "NOAA6" and "GOESE", are orbiting the Earth. "GOESE" has one circular on-nadir sensor attached. "NOAA6" has one off-nadir circular sensor and one off-nadir rectangular sensor attached. A solar terminator and subsolar point are shown moving across the planet . The ground observer icon appears in both the overview window and the Cartesian projection. A line segment between "NOAA6" and "GOESE" in the overview window shows that the two satellites have line-of-sight visibility.

MVA prompts for VEHICLE and SENSOR names. Up to 50 vehicles may be animated at once, each with up to 10 sensors attached (PS300 memory permitting). The following terminal session demonstrates the MVA command.

```
POP> MVA

On each line enter a vehicle name followed by
zero to ten sensor names (separated by spaces).
Enter a blank line to end the input.
-> GOESE SEN1
-> NOAA6 SEN2 SEN3
->
POP>
```

All of the items in the VEHICLE record except those in the second screen are used in MVA. The simulation time for the animation starts at the earliest start time of the vehicles input. The stop time is the latest stop time of the vehicles input.

The PS300 function keys and dials are presented in Tables 8 and 9, respectively.

Keyset #1

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Toggle views.
5		
6	SHADOW	Toggle planetary shadow.
7	TAGS	Toggle vehicle tags (names).
8	VEHICLES	Toggle vehicle icons.
9	TRAJECTS	Toggle vehicle trajectories.
10	PLANET	Toggle planet in overview.
11	SAT LINK	Toggle satellite to satellite links.
12	GND LINK	Toggle ground station to satellite links.

Keyset #2

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Toggle views.
5		
6	STARS	Toggle stars in the sky view.
6*	STARS	Toggle stars in the overview.
6+	STARS	Toggle star magnitudes in sky view and overview.
7	SKY DATA	Toggle sky view labels.
8	OBSERVER	Toggle ground observer icons.
9		
10		
11		
12		

Keyset #3

Key	Label	Function
1	MOTION	Toggle motion.
2	KEYS	Toggle keysets.
3	DIALS	Toggle dialsets.
4	VIEWS	Toggle views.
5		
6	TRMNATOR	Toggle solar terminator on flat map.
7	VEHICLES	Toggle vehicle icons.
8	VEHICLES	Toggle vehicle icons.
9	TRACES	Toggle ground traces.
10	STATIONS	Toggle ground stations.
11	SKY GRID	Toggle viewing grid in sky view.
12	MAP	Toggle flat map grid and features.
12*	MAP	Toggle map grid only.

* Press SHIFT key.
\+ Press CONTROL key.

Table 8 MVA - Function Keys

Dialset #1

Dial	Label	Function
1	HORZNTAL	Translate the overview horizontally.
2	VERTICAL	Translate the overview vertically.
3	DEPTH	Translate the overview in Z (depth cueing).
4	SCALE	Scale the overview.
5	X ROTATE	Rotate the overview in the X direction.
6	Y ROTATE	Rotate the overview in the Y direction.
7	Z ROTATE	Rotate the overview in the Z direction.
8	VEH SIZE	Scale the vehicles.

Dialset #2

Dial	Label	Function
1	LATITUDE	Move ground observer in latitude.
2	LNGITUDE	Move ground observer in longitude.
3	ALTITUDE	Move ground observer in altitude.
4	SCA FRUS	Scale ground observer frustum.
5		
6		
7		
8	FOV-GR	Ground observer field of view.

Table 9 MVA - Dialsets

ORIGINAL PAGE IS
OF POOR QUALITY

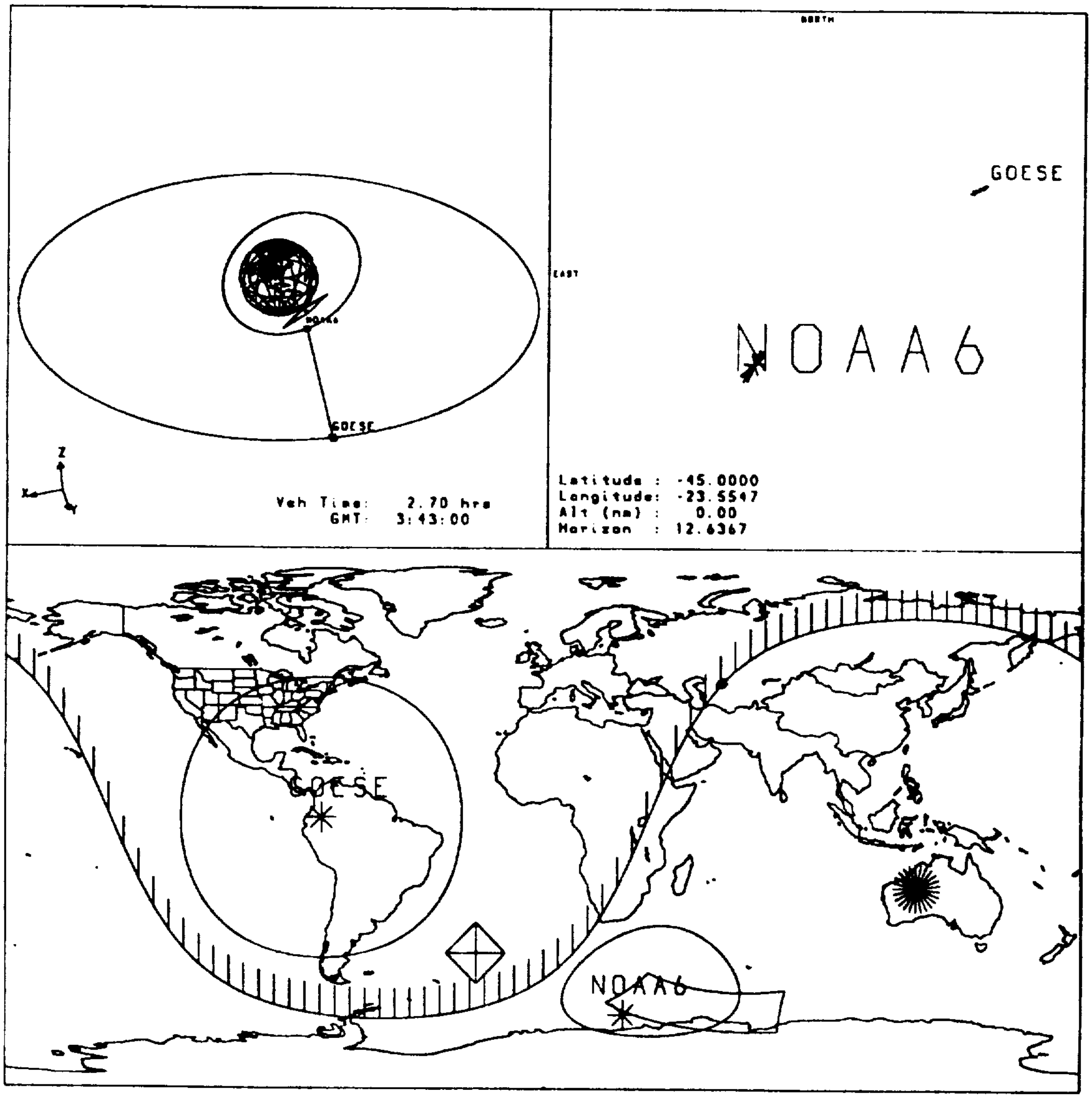

Figure 5 - Still Picture from MVA

7.0 CC - Cumulative Coverage

Cumulative Coverage (CC) calculates cumulative satellite sensor coverage as well as average and maximum revisit time for the entire surface of a planet for some simulation time interval. Cumulative coverage is defined as the total time that a point (an area on a planet approximately 21' of longitude by 21' of latitude) is covered by at least one sensor. A point on a planet is said to be *visited* when it is covered by one or more sensors at a particular instant of time. Revisit time is the length of time between successive visits of a point. Average and maximum revisit times are the respective average and maximum of a point's revisit times. In other words, these terms refer to individual points, not an average and maximum of all points. Revisit times of one time step (time increment in the global data) are not used in the calculation of average revisit time, since they indicate the point was continuously covered between two successive time steps.

CC is a batch-oriented program which produces three color-coded, raster pictures of the coverage data in the form of 1024 x 512 pixel Cartesian projections of either the Earth, Moon, or Mars. Each pixel corresponds to a point on a planet. One picture represents the cumulative time of coverage. Another picture represents the average revisit time. The last picture represents the maximum revisit time. A labeled color or greyscale bar is appended to each picture to yield three 1024 x 800 pixel images. Figure 6 is a greyscale image of the cumulative coverage produced by a system of two satellites, each with two off-nadir sensors attached.

The following terminal session creates a detached process to calculate the cumulative coverage and revisit time for three vehicles. A generic raster file containing all three pictures is written to the file "COV1.DAT". The DISPCC utility module may be used to display the pictures when the process completes.

```
POP> CC
On each line enter a vehicle name followed by
zero to ten sensor names (separated by spaces).
Enter a blank line to end the input.
-> SAT1 SEN1 SEN2
-> SAT2 SEN3
-> SAT3 SEN1 SEN3
->

Enter coverage filename [COVERAGE.DAT] -> COV1.DAT
POP>
```

The detached process will be named "CC_*Current time*". The current time is taken from the VAX/VMS system clock to create the process. The generic raster file will be written when the process completes. The VAX/VMS "SHOW SYSTEM" command may be used to determine the status of the process.

CC requires relatively long simulation runs with a short global time increment (in the GLOBAL data) for the best results. The sensors will tend to *skip* across the surface of the planet if the global time increment is too long. Typical runs can take from several hours to several days of CPU time.

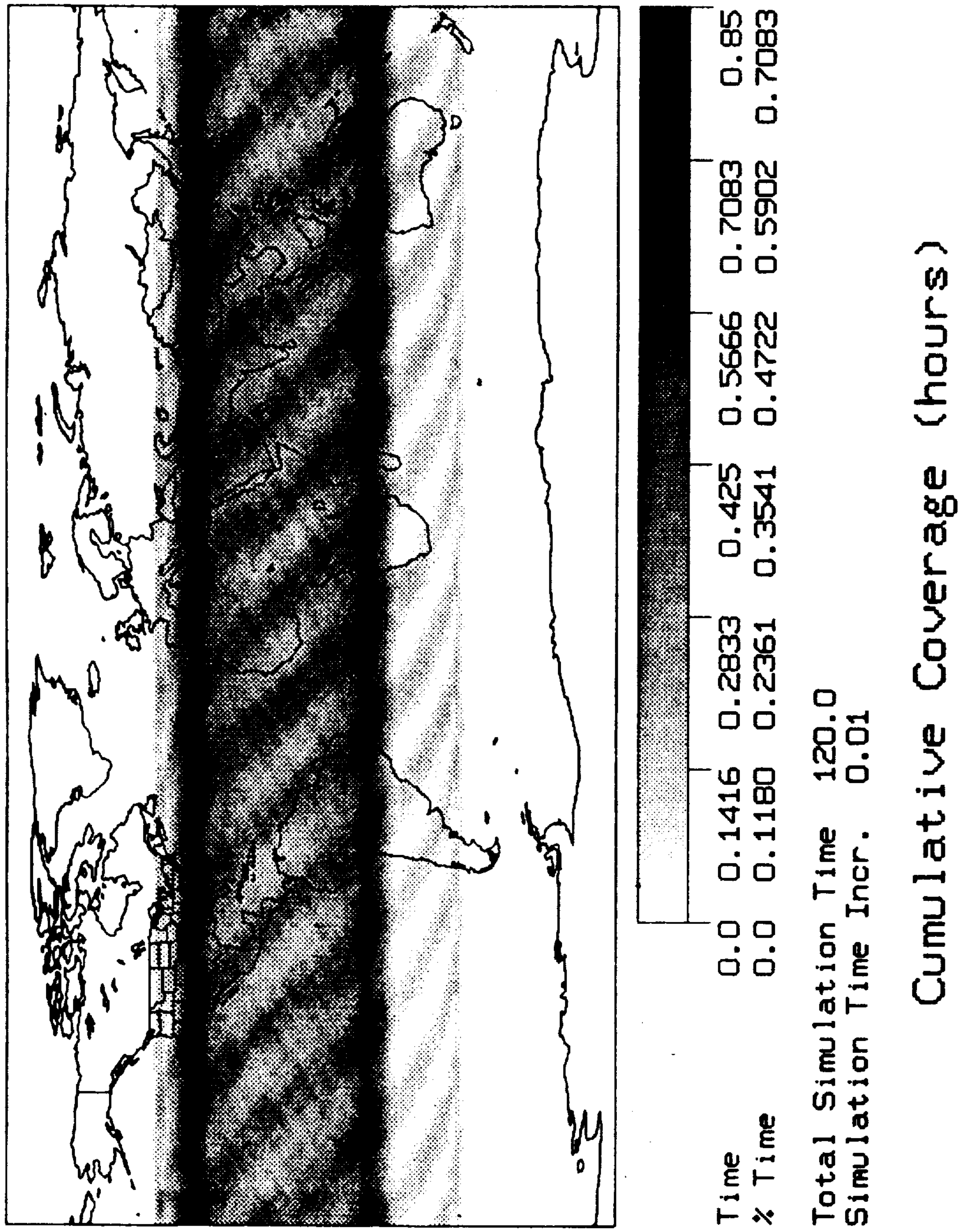

Figure 6 - CC / DISPCC PostScript Picture

8.0 DISPCC

The SODA utility module DISPCC may be used to draw CC pictures on a PS390 or to produce PostScript files and SDRC I-DEAS Picture files. DISPCC prompts for the CC generic raster filename. The maximum and minimum values of all points (pixels) on the planet are determined for the cumulative coverage time, average revisit time, and the maximum revisit time. A menu is presented that allows these values to be changed. When comparing multiple runs of CC it is often desirable to fix the color or grey range across runs. All pixels above the range are printed with maximum color or grey value. All pixels below the range are printed with minimum color or grey value. A menu of output options is presented after the ranges have been determined. The following terminal session demonstrates the DISPCC command.

```
POP> DISPCC

Enter coverage filename [COVERAGE.DAT] -> COV1.DAT

Actual Color Window (hours)

Cumulative Coverage Time........... 0.0 : 1.7
Average Revisit Time............... 0.2 : 11.5
Maximum Revisit Time............... 0.2 : 11.5


Set New Color Window (hours)

1 - Min Cumulative Coverage Time... 0.0
2 - Max Cumulative Coverage Time... 1.7
3 - Min Average Revisit Time....... 0.2
4 - Max Average Revisit Time....... 11.5
5 - Min Maximum Revisit Time....... 0.2
6 - Max Maximum Revisit Time....... 11.5

Enter an item number to be set or X to return -> X


Select Device/file type :

1 - Coverage on PS390 Terminal
2 - Avg. Revisit on PS390 Terminal
3 - Max. Revisit on PS390 Terminal
4 - PostScript Files
5 - IDEAS**2 Picture Files (binary)

-> 4

Cum. Coverage will be written to COVERAGE.PSC
Avg. Revisit will be written to  COVERAGE.PSA
Max. Revisit will be written to  COVERAGE.PSM

POP>
```

References

1 Foley, J. D.; Van Dam, A. : Fundamentals of Interactive Computer Graphics, Addison Wesley, 1982

2 "Guide to Programming on VAX/VMS (FORTRAN Edition)", Order No. AA-Y503A-TE, Version 4.0, Digital Equipment Corp., September 1984.

3 Gura, I. A.; Casten R. G. : "Astrolib User's Guide", Aerospace Report No. TOR-0081(6434-01)-3, The Aerospace Corporation El Segundo, Ca. 90245, February 1981.

4 "PS390 Document Set (E&S #901194-400)", Version A3.V01, Evans & Sutherland Computer Corp. P.O. Box 8700, 580 Arapeen Dr. Salt Lake City, Utah 84108

5 "RIM - VERSION 7 Relational Information Management System and Report Writer User's Guide", Central Scientific Computing Complex Document Z-4, NASA Langley Research Center, Hampton Va, May 1986.

6 Stallcup, S. S. : "FLEXAN (Version 2.0) User's Guide", NASA Contractor Report 4214, Computer Sciences Corporation. January 1989.

NASA
National Aeronautics and Space Administration

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-181932		

4. Title and Subtitle

Spacecraft Orbit Design and Analysis (SODA)
Version 1.0
User's Guide

5. Report Date

August 1989

6. Performing Organization Code

7. Author(s)

Scott S. Stallcup
John S. Davis

8. Performing Organization Report No.

TAO 50342

10. Work Unit No.

506-49-21-02

9. Performing Organization Name and Address

Computer Sciences Corporation
3217 North Armistead Avenue
Hampton, Virginia 23666

11. Contract or Grant No.

NAS1-17999

13. Type of Report and Period Covered

Contractor Report

12. Sponsoring Agency Name and Address

National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

14. Sponsoring Agency Code

15. Supplementary Notes

Langley Technical Monitors: John E. Hogge (COTR)
Lawrence F. Rowell

16. Abstract

This document describes the Spacecraft Orbit Design and Analysis (SODA) computer program, Version 1.0. SODA is a spaceflight mission planning system which consists of five program modules integrated around a common database and user interface. SODA runs on a VAX/VMS computer with an EVANS & SUTHERLAND PS300 graphics workstation. BOEING RIM-Version 7 relational database management system performs transparent database services. In the current version three program modules produce an interactive three dimensional (3D) animation of one or more satellites in planetary orbit. Satellite visibility and sensor coverage capabilities are also provided. Circular and rectangular, off-nadir, fixed and scanning sensors are supported. One module produces an interactive 3D animation of the solar system. Another module calculates cumulative satellite sensor coverage and revisit time for one or more satellites. Currently Earth, Moon, and Mars systems are supported for all modules except the solar system module.

17. Key Words (Suggested by Author(s))

Orbital Mechanics
Mission Planning
Sensor Coverage
Animation

18. Distribution Statement

Unclassified-Unlimited
Subject category - 61

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	46	A03

NASA FORM 1626 OCT 86

NASA
FORMAL
REPORT